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PREDICTING MATHEMATICS PERFORMANCE:

A STRUCTURAL EQUATION MODEL

BY

LINDA N. BRUNO

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

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Abstract

The relationships among personality and socialization factors that may contribute to mathematics performance were investigated using structural equation modeling. Five nested models were examined: a full model, a mediational model, a model eliminating the mediator, a regression model, and a model combining the significant paths from other models. Preliminary analyses (i.e., MANOVAS, follow-up univariate ANOVAS) revealed that men reported significantly higher math self-efficacy than women. Evaluation of the structural models identified the full model as the best representation of the data. This model examined the relationships among gender, gender schema, math anxiety, math self-efficacy, math attitude, math experience, math socialization, cognitive mediation, and math performance. Its hypothesis that direct paths from independent constructs to math performance would not be significant and that the direct paths to and from general ability would be crucial was supported. The full model accounted for 57% of the variance in math performance and 30% of the variance in general ability. These results suggest that the relationships among these variables function through the mediation of general ability. Interviews conducted with a small sub-set of the college-aged participants emphasized the role of elementary through high school teachers. This research clarifies conflicting findings concerning the predictors of math performance; specifically refuting the often made claim that men are inherently better at math; suggesting that teachers' and parents' attitudes about children's math abilities may contribute to the development of strong math self-efficacy and a lessening of math anxiety, particularly pointing to the need for teachers to express equal math expectations for both boys and girls.

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TABLE OF CONTENTS

	PAGE
ABSTRACT	ii
ACKNOWLEDGMENTS	iii
LIST OF APPENDICES	v
LIST OF TABLES	vi
LIST OF FIGURES	vii
STATEMENT OF THE PROBLEM	1
JUSTIFICATION AND SIGNIFICANCE OF THE STUDY	1
HYPOTHESES	8
METHOD.	9
PARTICIPANTS	9
MEASURES	10
PROCEDURE	13
RESULTS	14
DISCUSSION	23
APPENDICES	30
TABLES	44
FIGURES	50
BIBLIOGRAPHY	56

LIST OF APPENDICES

	PAGE
Appendix A Demographic Data	30
Appendix B Bem Sex Role Inventory	31
Appendix C Math As A Male Domain Scale	32
Appendix D Mathematics Anxiety Rating Scale	33
Appendix E Mathematics Anxiety Scale	34
Appendix F Math Self-Concept Scale	35
Appendix G Mathematics Self-Efficacy Tasks	36
Appendix H Attitude Toward Mathematics Scale	37
Appendix I Usefulness of Mathemtics Scale	38
Appendix J Math Experience	39
Appendix K Teachers' Attitude Scale	40
Appendix L Mother's Attitude Scale	41
Appendix M Father's Attitude Scale	42
Appendix N Follow-Up Interview Schedule	43

LIST OF TABLES

	PAGE
Table 1	Pearson's Correlations Among Dependent Measures 44
Table 2	Factor Loadings for Six-Component PCA Solution 45
Table 3	Descriptive Statistics for the Final Set of Measured Variables 46
Table 4	Pattern of Means by Gender 47
Table 5	Pattern of Means by Sex Role 48
Table 6	Correlations Among Exogenous Measured and Latent Variables in Models 1, 2, and 3 49

LIST OF FIGURES

	PAGE
Figure 1 Model 1	51
Figure 2 Model 2	52
Figure 3 Model 3	53
Figure 4 Model 4	54
Figure 5 Model 5	55

Predicting Mathematics Performance: A Structural Equation Model

Statement of the Problem

Mathematics presents a problem for many students who feel that they are inadequate and ineffectual in the realm of numbers and their manipulations. Many variables, examined individually (i.e., ability, sex, gender schema, experience with mathematics, socialization concerning mathematics, mathematics anxiety, attitude toward mathematics, self-efficacy regarding mathematics), have been shown to be related to mathematics performance. Some studies have investigated limited combinations of these factors. Yet, few have brought all these variables together in a single study. The present study intends to do so. Because of the complexities of the relationships, both demonstrated and anticipated, a structural equation model will be used in an attempt to clarify the issue. A central hypothesis of this study is that gender schema functions over and above gender to predict math performance.

Justification and Significance of the Study

The notion that men are simply superior to women in mathematical ability has been both supported and refuted. Some studies have shown that merely being male can predict better math achievement scores (Hackett, 1985; Lent, Lopez, & Bieschke, 1991) and the likelihood of choosing science-based college majors (Betz & Hackett, 1983). Hallinan and Sorensen (1987) demonstrated that sex was a factor in the assignment of fourth through seventh grade students to mathematics ability groups: boys were more likely than girls to be assigned to the high-ability group. Others do not find such clear differences. Fennema and Sherman (1977) uncovered sex differences favoring men at only two of the four high

schools they studied. Midkiff, Burke, and Helmstadter's (1989) path analytic study of adolescents uncovered no differences in math performance for boys and girls. In an extensive review of the literature, Meece, Parsons, Kaczala, Goff, and Futterman (1982) found that sex differences on tests of quantitative skills did not appear with any consistency before the 10th grade. Similarly, when Selkow (1985) accounted for the number of math courses taken beyond basic college arithmetic, she did not find sex differences in math ability either. Cooper and Robinson (1989) were also unable to uncover any significant sex differences in math ability for a large sample of math-talented college men and women. Yet, Benbow and Stanley (1980, 1983) showed that gifted seventh grade boys performed better than their female counterparts on mathematics reasoning ability tasks. Although aspects of Benbow and Stanley's studies have been criticized, this finding is important because at the seventh grade level, there would have been no substantive differences in the type and/or number of math courses taken by girls and boys.

However, gender differences (i.e., those based on socialization processes rather than biological sex) have been identified in several variables that relate to math performance. For example, one's attitudes toward math have been found to correlate positively with math performance, with men reporting more favorable attitudes concerning mathematics than those reported by women (Aiken, 1979; Rounds & Hendel, 1980a).

In college students, the amount of experience one has had with math has been shown to influence the selection of science-based (Betz & Hackett, 1983) and math-related college majors (Hackett, 1985), the adoption of math-related career goals (Singer & Stake, 1986), and one's level of mathematics achievement (Hackett, 1985). Experience

with mathematics has also been found to correlate negatively with math anxiety (Betz, 1978) and positively with math self-efficacy (Hackett, 1985). Therefore, in addition to mathematics experience, math anxiety and math self-efficacy must be accounted for when predicting math performance.

In doing so, math self-efficacy has been shown to be positively related to both math achievement and math attitude (Hackett & Betz, 1989; Rounds & Hendel, 1980a; Randhawa, Beamer, & Lundberg, 1993), with men reporting higher levels of mathematics self-efficacy than women (Lent et al., 1991; Lent, Lopez, & Bieschke, 1993; Matsui, Matsui, & Ohnishi, 1990; Pajares & Miller, 1994; Randhawa et al., 1993). Campbell and Hackett (1986) found that even women who performed well in math attributed their success to luck rather than ability. Betz and Hackett (1983) studied the relationship between math self-efficacy and math anxiety and found them to be inversely related. Furthermore, it has been demonstrated that mathematics self-efficacy explains a significant portion of the variance in math performance, over and above what is accounted for by math skills (Siegel, Galassi, & Ware, 1985) and that mathematics self-efficacy alone can predict mathematics achievement (Lent et al., 1993; Randhawa et al., 1993). Mathematics self-efficacy has also been shown to predict science-based preferences in career choices (Lent et al., 1991) and college majors (Betz & Hackett, 1983), as well as lowered math anxiety (Hackett, 1985).

Considerable research has been conducted in the area of math anxiety, most of which has found that women report higher levels of math anxiety than men (Bander & Betz, 1981; Llabre & Suarez, 1985; Pajares & Miller, 1994; Richardson & Suinn, 1972; Shiomi, 1992; Tobias, 1987). Betz (1978) found that in lower level math courses, college

women reported higher math anxiety than college men, but that upper level male and female students displayed no significant differences in math anxiety. Cooper and Robinson (1989) also found no gender differences in math anxiety in a math-talented college sample with similar ability; however, math anxiety did have an influence on math performance. In contrast, Llabre and Suarez (1985) demonstrated that when Scholastic Aptitude Test Math scores were introduced as a control for math aptitude, math anxiety did not predict performance.

Another viable explanation for the diverse findings on gender differences in math performance is that the women in upper level college math courses may not be stereotypically feminine gender-typed. Androgynous women have been reported to attain higher academic achievement than non-androgynous women (Heilbrun & Han, 1984). In fact, masculine and undifferentiated gender schematic individuals, regardless of sex, have also been shown to achieve significantly higher math scores than feminine sex-types (Olds & Shaver, 1980; Selkow, 1985). Generally, those who describe themselves as more masculine and less feminine have had better math performances (Signorella & Jamison, 1986). Gender schema has also been shown to relate to math anxiety. Masculine gender-typed women have displayed lower levels of math anxiety than any other gender schematic women (Bander & Betz, 1981; Heilbrun & Han, 1984); whereas feminine gender-typed men have tended to report higher levels of anxiety than other gender schematic men (Bander & Betz, 1981). Those with masculine gender schemas also appear to have higher math self-efficacy (Betz & Hackett, 1983; Hackett, 1985; Hackett & Betz, 1989) which has accounted for a significant amount of variance in math performance over and above what is accounted for by math skills (Siegel et al., 1985).

It has also been proposed that stereotypical gender-typed attitudes toward math expressed by significant others may influence one's own attitude and subsequent math performance (Eccles & Jacobs, 1986). Tobias and Weissbrod (1980) argued that socialization processes discouraged girls and women from excelling in mathematics. Fennema and Sherman (1978) confirmed this when they found that boys perceived their parents and teachers as more positive toward their learning mathematics than did girls. Meece et al. (1982) concluded that the attitudes of teachers and parents may reflect the stereotype of male math superiority as well as a sense that math skills are more useful for boys than girls; thus undermining girls' confidence, motivation, and ultimate performance in mathematics.

Furthermore, the function of ability as a mediator between personal attributes and math performance must also be considered. Fennema and Sherman (1977) pointed out the importance of general ability in the learning of mathematics. When Cooper and Robinson (1991) used math ability as a control variable, it accounted for 48% of the variance in math performance. Siegel et al. (1985) also reported that math aptitude accounted for a significant amount of variance in math performance, while math anxiety, sex, and gender schema did not. Conversely, Adams and Holcomb (1986) concluded that math performance was affected by the interaction of math attitude, math anxiety, and basic math skills regardless of overall intellectual level.

The extensive research in this area lends credence to the importance of the issue while suggesting complex and diverse relationships among multiple variables. Differences between men and women regarding math achievement are sometimes identified, and sometimes not. When found, some researchers hold that they are a manifestation of innate

sex differences in mathematical ability; whereas others contend that such differences in math performance are a result of the socialization process and the prevalence of stereotypical gender roles. Although gender is not consistently linked to math performance, it has been associated with several variables that are, such as men's more positive attitudes toward mathematics. This, in turn, has been positively correlated with math self-efficacy which is positively related to math experience which negatively correlates with math anxiety, which men report far less often than women. Add to all this the impact of gender role stereotyping and the confusion over differentiating between math ability, math achievement, and math performance and the need for further investigation becomes apparent.

The task of distinguishing math ability from math achievement and/or math performance is an important and salient issue because the role of ability as a cognitive mediator is a major component of this research project. Math ability has been variously operationalized as the American College Test - Mathematics (ACT-M) score (Cooper & Robinson, 1989, 1991), a test considered analogous to the Scholastic Aptitude Test - Mathematics (SAT-M); as the Wechsler Adult Intelligence Scale (WAIS) Arithmetic subtest score (Selkow, 1985); and as standardized test scores based on the SATs (Singer & Stake, 1986). References have also been made to "math reasoning ability" (Benbow & Stanley, 1980, 1983) and "math aptitude" (Siegel et al., 1985) with the SAT-M being used to measure both these constructs. "Mathematics performance" has most often been operationalized as actual course or teacher designed test grades (Jacobs, 1991; Norwich, 1987; Rounds & Hendel, 1980a; Siegel et al., 1985; Watson, 1987), although Lent et al. (1991) used the ACT-M for this purpose. To further complicate things, Benson (1988)

and Randall (1990) measured “math achievement” with course grades, while Betz (1978) utilized the ACT-M to this end. None of the studies cited examined these nomological and operationalizing issues.

The majority of the research in this area conducted during the early and mid-1980s was concerned with the comparison of mean differences on the several variables mentioned above (Benbow & Stanley, 1980, 1983; Campbell & Hackett, 1986; Heilbrun & Han, 1984; Olds & Shaver, 1980; Selkow, 1985; Singer & Stake, 1986). Since the mid-1980s, most studies have investigated the variables related to mathematics using regression procedures (Cooper & Robinson, 1989; Gerardi, 1990; Lent et al., 1991; Matsui et al., 1990; Norwich, 1987; Randall, 1990; Siegel et al., 1985; Signorelli & Jamison, 1986; Watson, 1987; Zuckerman, 1991) or path analysis (Eccles & Jacobs, 1991; Hackett, 1985; Jacobs, 1991; Llabre & Suarez, 1985; Midkiff et al., 1989; Pajares & Miller, 1994; Stipek & Gralinski, 1991).

The present study assessed the combination of these variables as a structural equation model (SEM) in an attempt to predict mathematics performance in a college-age sample. Only a few studies in this area have used this technique (Benson, 1988; Marsh, 1987; Meece, Wigfield, & Eccles, 1990; Randhawa, Beamer, & Lundberg, 1993), which provides a comprehensive and appropriate method for thoroughly examining the relationships of several independent constructs with mathematics performance. I used structural equation modeling to examine these types of relationships as they function through a cognitive mediator. In addition, I analyzed the mean differences for sex and gender schema in two sets of multivariate analysis of variance (MANOVA).

I set out to examine four structural models. Model 1 investigated the relationships among sex, gender schema, math anxiety, math efficacy, math attitude, math experience, math socialization, a cognitive mediator, and math performance. Model 2 eliminated the cognitive mediator, assessing only the direct relationships among the remaining constructs. Model 3 examined relationships only as they function through the cognitive mediator. Model 4 treated the cognitive mediator as an independent construct.

I considered the following hypotheses:

- (1) Model 1 will adequately represent the data,
 - (a) direct paths from independent constructs to math performance will not be significant,
 - (b) indirect paths to and from the cognitive mediator will be crucial;
- (2) Model 2, without the cognitive mediator, will not be as good a representation of the data as Model 1;
- (3) Model 3 will fit the data reasonably well, and more appropriately than Model 2;
- (4) In Model 4, mathematics performance can be directly predicted from
 - (a) gender-schema, where those with feminine gender-schema will have poorer performance than those with non-feminine gender-schema;
 - (b) math anxiety, expected to be negatively related to math performance;
 - (c) math self-efficacy, hypothesized to be positively related to math performance;
 - (d) math attitude, expected to be positively related to math performance;
 - (f) math socialization, where perceived favorable math attitudes of significant others will be positively related to math performance;

(g) the cognitive mediator, also expected to be positively related to math performance;

(5) Sex differences will occur, such that compared to women, men will

- (a) report less math anxiety,
- (b) exhibit more math self-efficacy,
- (c) display more positive attitudes toward mathematics;
- (d) have better math performance;

(6) Depending on one's gender-schema, differences will exist, such that compared to other schemas, individuals with feminine gender-schemas will

- (a) express more math anxiety,
- (b) demonstrated less math self-efficacy,
- (c) report less favorable attitudes toward mathematics,
- (d) show poorer math performance.

Method

Participants

College students ($N = 243$) representing various majors (e.g., business, computer science, education, nursing, pharmacy, psychology, sociology) were recruited from introductory level psychology courses at the University of Rhode Island. Of these, 29 were eliminated from the analyses because of special education needs ($n = 6$), English as a second language ($n = 19$), or incomplete data ($n = 4$). Among the remaining 214 participants, there were 72 men and 142 women. Participants ranged in age from 17 to 26 years ($M = 18.78$, $SD = 1.17$). All participants received course credit for taking part in this study.

SAT-V and SAT-M scores were not available for 66 participants who otherwise provided complete data. To predict the missing SAT scores, two standard regressions were performed using the Statistical Package for the Behavior Sciences (SPSS) with Wonderlic scores as the independent variable in each analysis. Results were significant using SAT-V as the dependent variable, $F(1,212) = 135.05$, $p < .05$, $B = 9.16$, Constant = 239.74. Significance was also found when SAT-M was the dependent variable, $F(1,212) = 51.33$, $p < .05$, $B = 7.36$, Constant = 327.94.

Measures

An appropriate demographic data questionnaire was administered along with several scales. Fifteen measures (X1 - X15) assessed the exogenous (measured independent) constructs and five measurements (Y1 - Y5) were taken for the endogenous (measured dependent) constructs. The choice of measures for each construct was based on a thorough consideration of the previous literature and adequately represented the entities being studied.

Sex. A demographic item was used to code sex (X1) as a dummy variable: Male = 0, Female = 1.

Gender Schema. The Masculinity score (X2) and the Femininity score (X3) of the Bem Sex Role Inventory (BSRI; Bem 1974), as well as the 12-item Math as a Male Domain (X4) subscale (split-half reliability = .87) of the Math Attitude Scale (MAS; Fennema & Sherman, 1976) assessed gender schema.

Mathematics Anxiety. Two scales measured math anxiety: (a) the 24-item shortened form of Richardson and Suinn's (1972) Mathematics Anxiety (X5) Rating Scale (MARS, Plake & Parker, 1982; internal consistency reliability estimate = .98, correlation

with full-scale MARS = .97), where high scores equal high anxiety; and (b) the 10-item revised version (Betz, 1978; split-half reliability estimate = .92) of the Math Anxiety Scale (X6) from Fennema and Sherman's (1976) Mathematics Attitude Scales (MAS), with low scores reflecting high levels of anxiety. For the purposes of this study's analyses, the revised MAS was reverse scored so that high scores represented high math anxiety. Although Rounds and Hendel (1980b) concluded that these two instruments measured somewhat different aspects of math anxiety, Cooper and Robinson's (1991) account of the Math Anxiety Scale's correlation with the MARS ($r = .68$) and with Sandman's Anxiety Towards Mathematics Scale ($r = .78$) provides evidence for convergent validity. Dew, Galassi, and Galassi (1983) also found that these three math anxiety measures were moderately related to each other. Bander and Betz's (1981) reported correlations of the Math Anxiety Scale with math background ($r = .19$ to $r = .43$), the ACT-M ($r = .73$ to $r = .84$), and a measure of confidence in learning mathematics ($r = .73$ to $r = .84$) further substantiate the scale's validity.

Mathematics Self-Efficacy. The 7-item Math Self-Concept (X7) Scale (internal consistency reliability estimate = .90; Benson, 1988) and Betz and Hackett's (1983) 18-item Math Self-Efficacy - Tasks (X8) Scale (internal consistency reliability estimate = .90) gauged math self-efficacy. Evidence for validity is provided by Benson's finding that higher scores on the Math Self-Concept Scale were associated with higher levels of both math achievement and math self-efficacy. The Math Tasks Scales' positive correlations with math confidence and low math anxiety ($r = .46$ and $r = .40$ respectively; Betz & Hackett) provide evidence for its validity.

Mathematics Attitude. Aiken's (1979) 24-item Attitudes Toward Mathematics (X9) Scale (alpha coefficient estimates range = .81 - .91) and 12-item Usefulness of Math (X10) subscale (split-half reliability estimate = .90) from the Fennema-Sherman (1976) MAS assessed math attitude. One-item on the Usefulness of Math Scale was slightly modified for use with college students. High scores indicate more favorable attitudes towards mathematics for both of these scales. Validity information for the Aiken scale is provided by Adams and Holcomb (1986) who found that it correlated negatively with math anxiety ($r = -.50$) and positively with skills in arithmetic ($r = .30$) and algebra ($r = .59$); and for Usefulness of Math, by its positive correlations ($r = .14$ to $r = .45$) with math achievement (Fennema & Sherman, 1977).

Math Experience. The number of math courses taken in high school (X11), as well as those taken in college (X12), were assessed in a checklist questionnaire and served as the basis for establishing participants' mathematics experience. Validity information is provided by Hackett's (1985) finding that the number of years of high school mathematics preparation predicted math achievement (i.e., ACT-M scores).

Math Socialization. Three 12-item subscales from the Fennema-Sherman (1976) MAS, each with split-half reliability of .89 (Fennema & Sherman, 1977), measured math socialization: Teachers' Attitude (X13), Mother's Attitude (X14), and Father's Attitude (X15). One item on both the Mother Scale and the Father Scale was slightly modified for use with college students. Fennema and Sherman's (1977) report of positive correlations for each of these scales with math achievement provides validity information.

Cognitive Mediator. Three measures were used to assess cognitive mediation: Scholastic Aptitude Test - Verbal (SAT-V) score (Y1), in that verbal skills are considered

to be important for math comprehension (Aiken, 1971); Scholastic Aptitude Test - Mathematics (SAT-M) score (Y2), which measures mathematical thinking calling for algebraic and geometric reasoning without giving an advantage to those who have taken many math courses (Cronbach, 1990); and The Wonderlic Personnel Test (Y3), a timed 12-minute 50-item multiple-choice test of general ability which has high levels of alternate forms reliability, typically exceeding .90 (Murphy & Davidshofer, 1988). Evidence for the Wonderlic's validity is provided by correlations in the high .70's with the original Wechsler Adult Intelligence Scale (WAIS) and the newer revised (WAIS-R) version (Kaufman, 1990) as well as significant correlations with basic arithmetic and algebra skills, $r = .56$ and $r = .44$ respectively (Adams & Holcomb, 1986). Murphy and Davidshofer (1988, p. 202) state that "the Scholastic Aptitude Test (SAT) is one of the most technically outstanding tests of general intellectual level...[and] can be validly regarded as a measure of general intelligence, since it primarily measures comprehension and reasoning ability rather than the knowledge of specific facts." Kaufman (p. 25) lends support to the use of the SAT as a measure of ability in his claim that "like the SAT, IQ tests assess..." intellectual skills and knowledge developed through experience; as does Hanson (1993) who contends that SATs are a close kin of IQ tests. Further, the SATs have internal consistency reliability estimates above .90 (Murphy & Davidshofer, 1988) and predictive validity estimates for college grades of .37 individually and .41 combined (Kaplan, 1982). SAT scores were obtained, with participants' permission, from student records.

Mathematics Performance. Two halves of a 25-item Graduate Record Examination - Quantitative (GRE-Q) practice test (Y4, odd numbered items; Y5, even numbered items) were used to assess mathematics performance (Gruber & Gruber, 1977;

beyond copyright). The GRE-Q relies on deductive quantitative reasoning and requires test takers to actively process, manipulate, and evaluate information. This test has an internal consistency reliability estimate above .90 (Murphy & Davidshofer, 1988).

According to Anastasi (1982), the GRE Aptitude test's quantitative items require both mathematical reasoning and the ability to interpret graphs, diagrams, and descriptive data.

Procedure

Several two-hour testing sessions were arranged. To assure anonymity, participation numbers were assigned with the demographic data sheet which was the first page of the test packet. The two timed tests, the GRE-Q and the Wonderlic, were presented next. To control for order effects, half the participants completed the GRE-Q before the Wonderlic while the other half were administered the Wonderlic prior to the GRE-Q. The remaining measures (i.e., Bem Sex Role Inventory; Math Anxiety Rating Scale; Math Self-Concept Scale; Aiken's Attitudes Toward Mathematics Scale; the Fennema-Sherman Subscales of Math as a Male Domain, Math Anxiety, Usefulness of Math, Teacher's Attitude, Mother's Attitude, and Father's Attitude; Math Self Efficacy - Tasks Scale) were ordered randomly in the research packets and administered following the two timed tests.

All measures were appropriately scored and the scores recorded for each participant according to his or her participation number. Participants were asked (on the demographic data form) if they would be willing to take part in a brief follow-up interview. Of those who agreed, one man and one woman ($N = 8$) from the following categories were interviewed via telephone: High Ability/High Performance (Wonderlic > 27/GRE > 10), High Ability/Low Performance (Wonderlic > 27/GRE < 8), Low

Ability/High Performance (Wonderlic < 19/GRE > 10), Low Ability/Low Performance (Wonderlic < 19/GRE < 8).

Results

Preliminary Analysis

A correlational analysis (i.e., Pearson's r) was performed using the Statistical Package for the Social Sciences (SPSS) to examine the relationship among three variables (i.e., SAT-V, SAT-M, Wonderlic) used as a single latent mediating construct representing General Ability. As shown in Table 1, all three variables were highly inter-correlated, with Pearson r coefficients ranging from .44 to .62. This analysis confirmed the use of SAT-V, SAT-M, and Wonderlic as indicators of a single latent cognitive mediator in subsequent analyses.

Principal Components Analysis

A principal components analysis (PCA) with oblique rotation was conducted using SPSS to form latent constructs for subsequent use in modeling analyses. A nine-component solution based upon the literature review (see Introduction) and consistent with the proposed SEM was requested. The variables entered into the PCA along with sex were the scores from the BSRI masculinity and femininity scales, Math as a Male Domain Scale, Math Anxiety Rating Scale, Math Anxiety Scale, Math Self-Concept Scale, Math Self-Efficacy -Tasks Scale, Attitudes Toward Mathematics Scale, Usefulness of Math Scale, Teachers' Attitude Scale, Mother's Attitude Scale, Father's Attitude Scale, SAT-V, SAT-M, Wonderlic, odd numbered GRE-Q items, and even numbered GRE-Q items, as well as the number of math courses taken in high school and also in college. The results of this PCA were difficult to interpret due to several complex loadings (i.e.,

variables loading on more than one component) and various single-item or two-item factors (see Gaudagnoli & Velicer, 1988 for a discussion of the need for a minimum of three variables to reliably and validly identify a latent construct).

Consequently, a second PCA with oblique rotation using the CAX software program (Velicer, 1976) was conducted in order to uncover a statistical solution to the number of components underlying the variables. The minimum average partial solution (see Velicer, 1976) produced the six-component solution shown in Table 2. The resultant component structure, however, was not consistent with the proposed structural model and several complex loadings remained. Therefore, the measurement models for the latent constructs were altered before conducting SEM analyses. BSRI-Masculine was eliminated because it loaded on more than one component. The Math Anxiety Component was not retained because it consisted of only one variable (Mathematics Anxiety Rating Scale). College Math Experience was eliminated to create a single measured variable representing Math Experience rather than retaining a two-item component (see Gaudagnoli & Velicer, 1988); in addition, the inclusion of College Math Experience did not add a significant amount of explained variance to the Math Experience component.

The next step of the analysis attempted a confirmatory factor analysis (CFA) using the EQS statistical package (Bentler, 1995). Despite the elimination of the six complex or two-item components, model convergence remained unattainable. As a result, the following changes were made to the structure of the independent variables: (a) Component 1 was divided into two separate, but correlated, independent variables; (b) Component 3 was divided into two separate independent variables; (c) the Math Anxiety Scale (X6) was retained as a single measured variable representing math anxiety; (d) Math

Self-Concept (X7), Math Self-Efficacy - Tasks (X8), Attitudes Toward Mathematics (X9), and Usefulness of Math (X10) were retained as one factor representing Math Efficacy and Attitude; (e) Teacher's Attitude (X13), Mother's Attitude (X14), and Father's Attitude (X15) were combined as the Math Socialization Factor; (f) Sex (X1) was separated out and used as a single measured variable; and (g) Math as a Male Domain (X4) was retained as a single measure of Gender-Schema and subsequently labeled as Math As A Male Domain.

SAT-V (Y1), SAT-M (Y2), and Wonderlic (Y3) were treated as three measured variables representing a latent construct labeled General Ability, which was examined as the mediating variable in subsequent model evaluation. Similarly, GRE-Q -- Odd (Y4) and GRE-Q -- Even (Y5) were treated as two measured variables which combined represented the latent construct of Math Performance, the dependent variable in subsequent model evaluation.

Descriptive Statistics

Table 3 displays the means, standard deviations, and ranges for the final set of measured variables. Several variables (e.g., Sex, BSRI-M, BSRI-F, Math as a Male Domain, Math Self Efficacy, Usefulness of Math, Teacher's Attitude, Mother's Attitude, Father's Attitude, SAT-M) showed moderate values. Others were less endorsed (e.g., Math Anxiety Rating Scale, College Math, SAT-V) as evidenced by lower averages relative to the possible range of scores for these variables.

Multivariate Analyses of Variance

Using SPSS, a one-way between-groups multivariate analyses of variance (MANOVA) was performed using sex as the independent variable and the remaining set of

measures as the dependent variables (DVs). Using Wilks' criterion, the combined DVs were significantly related to sex, with Wilks' Lambda = .85, $F(16, 197) = 2.17$, $p = .007$, indicating 15% shared variance (i.e., $1 - \text{Wilks' Lambda}$) between sex and the remaining measures. As expected, follow-up univariate analysis of variance (ANOVA) showed that men reported significantly higher math self-efficacy ($M = 118.42$) than did women ($M = 106.74$), $F(1, 212) = 8.44$, $p = .004$, and had taken significantly more college math courses, $F(1, 212) = 5.57$, $p = .019$, ($M = 1.26$ and $M = .91$ respectively). Women's higher scores on the Wonderlic ($M = 22.676$) as compared to those of men ($M = 21.44$) approached significance, $F(1, 212) = 3.81$, $p = .052$ (see Table 4).

A second one-way between-groups MANOVA was performed using gender schema as the grouping independent variable with four levels (feminine, masculine, androgynous, undifferentiated) and the remaining set of measures as the dependent variables. Gender schema categories were determined by the median-split method: Masculine = $\text{BSRI-M} \geq 98$, $\text{BSRI-F} \leq 100$ ($n = 55$); Feminine = $\text{BSRI-M} \leq 97$, $\text{BSRI-F} \geq 101$ ($n = 53$); Androgynous = $\text{BSRI-M} \geq 98$, $\text{BSRI-F} \geq 101$ ($n = 58$); Undifferentiated = $\text{BSRI-M} \leq 97$, $\text{BSRI-F} \leq 100$ ($n = 48$). With the use of Wilks' criterion, the combined DVs were significantly associated with gender schema, Wilks' Lambda = .72, $F(48, 580) = 1.44$, $p = .032$. However, the only significant univariate ANOVA was unrelated to the hypotheses; androgynous individuals scored significantly lower than undifferentiated participants on both SAT-V and SAT-M, $p < .05$ (see Table 5).

Structural Equation Models

I used structural equation modeling (SEM) with the EQS (Bentler, 1995) computer program to assess the combination of the variables under investigation in an

attempt to predict mathematics performance. SEM is a statistical technique consisting of a set of procedures designed to analyze hypothesized relationships among a set of latent constructs, each measured by one or more observed variables. SEM is rarely used to evaluate a single model; ideally, several alternative models are considered in an attempt to identify the model that best fits the data. The goodness of fit between the observed data and proposed models is evaluated by three criteria: (a) theoretical consistency, i.e., theory provides some support for the model; (b) empirical evidence (based on several indices of fit, as explained below); and (c) parsimony, i.e., when more than one model fits the data equally well, the model with the fewest parameters is retained (see Harlow & Rose, 1994).

Empirical evidence refers to the statistical evaluation of the model using several criteria. A frequently used overall model fit index is the chi-square (χ^2) to degrees of freedom (df) ratio, where it is hoped that the ratio of chi-square to degrees of freedom will be less than 2; retaining the null hypothesis with a probability level greater than .05 indicates that the model adequately fits the data. However, chi-square can not be the sole criteria for model evaluation because of its dependency on sample size. Consequently, the Average Absolute Standardized Residual (AASR) and Bentler's (1995) Comparative Fit Index (CFI) will be considered to assess the fit between the proposed models and the observed data; values lower than .05 for the AASR and closer to 1.0 for the CFI suggest better model fit.

Structural models are also evaluated in terms of the explained variance in each dependent construct (R^2 , a measure of effect size; e.g., Cohen, 1992). When comparing several models that are nested within a larger Full model, the importance of the eliminated paths is evaluated by subtracting the χ^2 and df values of alternative models from the

baseline Full Model and testing the significance of the χ^2 difference. If there is a significant difference in chi-square values (i.e., probability less than .05), the Full model should be retained; the reduced model is not explaining the data as well. In this analysis, several models were evaluated to assess the relationships among personality and socialization variables, gender, gender schema, cognitive mediation, and mathematics performance.

Model 1 (Full Model), displayed in Figure 1, examined the relationships among sex, gender schema, math anxiety, math efficacy, math attitude, math experience, math socialization, the cognitive mediator, and math performance, hypothesizing that the direct paths from independent constructs to math performance would not be significant and that the direct paths to and from the cognitive mediator would be crucial. This model is well grounded in theory, exhibits good empirical evidence ($\chi^2 (80) = 205.99$, $p < .001$; CFI = .91; AASR = .05), and is relatively parsimonious. Several of the hypothesized parameters (i.e., all direct paths from exogenous variables to math performance) were insignificant, while several other parameters were significant. Correlations among exogenous measured and latent variables are shown in Table 6. The proportion of explained variance in the cognitive mediator ($R^2 = .30$) and math performance ($R^2 = .57$) indicated large to very large effect sizes respectively (see Cohen, 1992). These results suggest that the direct regression paths from the exogenous variables to math performance are not necessary and that, indeed, the relationships function through general ability.

Model 2, shown in Figure 2, eliminating general ability as a cognitive mediator, has rather weak theoretical grounding and poorer empirical fit ($\chi^2 (87) = 293.58$, $p < .001$; CFI = .85; AASR = .09); although it is inherently parsimonious. Correlations among

exogenous measured and latent variables are shown in Table 6. As expected, this model was not as good a representation of the data as Model 1. The proportion of explained variance in math performance was moderate ($R^2 = .25$). No direct paths from exogenous variables to math performance were significant, leading to the conclusion that general ability can not be eliminated in considering the predictors of math performance.

Evaluating the importance of the eliminated paths in this model through a chi-square difference test ($p < .001$) revealed that this reduced model does not explain the variance and covariance in the data as well as the Full Model.

Model 3 (Mediational Model), presented in Figure 3, considering relationships only as they function through general ability, has impressive theoretical support and relatively good parsimony displaying good empirical evidence ($\chi^2 (86) = 230.66$, $p < .001$; CFI = .90; AASR = .06). Direct paths from exogenous variables (with the exception of sex) to general ability were significant, as was the direct path from general ability to math performance. Correlations among exogenous measured and latent variables are shown in Table 6. The proportion of explained variance in the cognitive mediator ($R^2 = .30$) and math performance ($R^2 = .42$) implied large to very large effect sizes. As hypothesized, this model fits the data reasonably well and more appropriately than Model 2, confirming that direct regression paths from the exogenous variables to math performance are not indicated as these relationships are mediated by general ability. Again a chi-square difference test ($p < .001$) showed that the Full Model provides a better explanation of the data than this reduced model. Furthermore, when comparing the Mediational Model's R^2 value for math performance with that of the Full Model, it is clear that 15% of the variance in math performance can be attributed to the set of exogenous constructs. This

means that there is significant variance directly associated with math performance that does not function through the cognitive mediator.

Model 4 (Regression Model), depicted in Figure 4, also has a strong theoretical basis, good empirical fit ($\chi^2(80) = 205.94$, $p < .001$; CFI = .91; AASR = .05), and better parsimony than the Full Model 1. However, the only direct path to math performance that proved significant was from general ability, which explained a large proportion of the variance ($R^2 = .57$) in math performance. The other hypothesized relationships between exogenous variables and math performance were not confirmed. These findings strongly suggest that general ability must be considered in any prediction model of math performance and provide evidence that general ability appears to serve as a mediator between relevant exogenous variables and math performance (as in the Mediational Model). An empirical distinction (chi-square difference test) between the Regression Model and the Full Model was not possible because the degrees of freedom were the same for both.

An additional SEM combining significant paths from other models, represented by Figure 5, was attempted in order to identify the “best model” for predicting math performance. This model had adequate empirical fit ($\chi^2(96) = 244.63$, $p < .001$; CFI = .90; AASR = .06) and good parsimony, revealing significant paths from gender schema, math anxiety, and high school math experience to general ability as well as a significant relationship between general ability and math performance. Further, the variance explained for general ability was moderate and that explained for math performance was rather large ($R^2 = .24$ and $R^2 = .42$ respectively). A chi-square difference test ($p < .005$) found that the Full Model was doing a better job explaining the data than this reduced

model. Also, the R^2 value for math performance again dropped from .57 in the Full model to .42, indicating that 15% of the variance in math performance can be attributed to the set of exogenous variables even though none of them individually were directly related to the outcome, except through the cognitive mediator.

Content Analysis

A thorough review of the eight follow-up interview transcripts revealed one dominant theme: higher teacher expectations for boys in regard to mathematics performance. Most of the college-aged men (50%) and women (75%) interviewed clearly reported higher teacher expectations for male students. Half of the respondents (three women and one man) emphasized that this inequality was most prevalent during junior high and high school. Interestingly, both high ability men indicated that even in grade school math classes, boys were called on more, got more help, were pushed harder, were expected to perform better, and were generally given more opportunities in mathematics and sciences than were girls.

Both the high ability/low performance respondents expressed somewhat negative attitudes toward math, citing their math teachers as having influenced their opinions. The attitudes of the two low ability/low performance students were clearly more negative. Both expressed the view that high school math had been difficult for them. The high ability/high performance interviewees held strong positive attitudes toward math and attributed their feelings to the logical nature of mathematics and its sense of immediate accomplishment. The low ability/high performance interview participants also expressed positive attitudes toward math, claiming that they had never had problems in math and that it seemed easier than other subjects.

None of the respondents suggested that their parents had manifested or imposed stereotypically gender-typed attitudes concerning math ability. Regardless of their individual abilities and performances as assessed in this study, all the interviewees felt that their parents had been pleased with, and supportive of, their early efforts in mathematics.

Only one person, the low ability/low performance male college student, expressed the opinion that women and men have different math abilities. Specifically, he stated that women were better in math and that his math tutors had all been women. The other interview participants unequivocally asserted that men and women have equal math abilities.

None of the interviewees ascribed to the suggestion that women who excel in math are less feminine. Similarly, they all disavowed the notion that men who do not perform well in math are perceived as less masculine. It may be that college age individuals have more androgynous views of math performance than do younger adolescents. This hypothesis could be examined in future studies using both qualitative and quantitative methods within several age ranges.

Discussion

The present study was designed to assess the relationship among sex, gender schema, math anxiety, math efficacy, math attitude, math experience, math socialization, general ability, and math performance. Specifically, the hypothesis that general ability acts as a mediator between personality and socialization attributes on one hand and mathematics performance on the other was tested. The results from five reasonable alternative models provided support for this hypothesis.

Without exception, none of the personality and socialization characteristics were directly associated with math performance. Contrary to previous findings (Cooper & Robinson, 1989; Eccles & Jacobs, 1986; Hackett, 1985; Lent et al, 1991; Siegel et al, 1985; Signorella & Jamison, 1986), none of these variables showed a direct relationship with mathematics performance in any of the models examined in this study. In fact, the Full Model (Model 1), which best explained the data, provided evidence that although gender schema, math anxiety, and math experience were not directly related to mathematics performance (as evidenced by non-significant pathways to mathematics performance), they were significantly related to general ability and thereby indirectly linked to math performance through the mediation of general ability. The Mediational Model, which adequately explained the data, though not as well as the Full Model, found only math anxiety and high school math experience to be indirectly related to math performance through the general ability mediator.

Interestingly, although sex was not significantly related to any other variables and/or factors, women were significantly more likely to view math as a male domain than were men. Furthermore, as regards gender schema, individuals who reported feelings that math was predominantly a male domain demonstrated significantly higher general ability and lower (although not significantly) math performance compared with those who did not exhibit this attitude. In their extensive review of the literature, Signorella and Jamison (1986) found that individuals who described themselves as more masculine and less feminine had better math performances. Similarly, Selkow's masculine gender-oriented participants performed better than her feminine gender-oriented participants on a test of

mathematics ability regardless of sex (1985). The present study did not support these findings, but rather pointed to the importance of the mediating role of general ability.

Although Model 1 did not support a significant link between gender schema and math anxiety, it did reveal a weak relationship in the predicted direction; those who were more likely to view math as a male domain reported higher math anxiety. However, other research has identified a significant relationship between gender schema and math anxiety using BSRI scores as indicators of gender schema. Heilbrun and Han (1984) showed that masculine gender-typed women display less math anxiety than other gender-typed women; similarly, Bander and Betz (1981) found that feminine gender schematic men reported higher math anxiety than other gender schematic men. The fact that the present study was unable to use BSRI scores in the structural models may account for the failure to identify a significant relationship between gender schema and math anxiety. Future research should focus on operationalizing gender-schema as BSRI scores, specifically the BSRI masculine score.

In addition, both gender schema and math anxiety were significantly related to the math socialization factor. Participants who were more likely to endorse math as a male domain and those who reported less math anxiety had experienced more positive mathematics socialization. A close examination of the raw data revealed that women recalled more positive attitudes about their math abilities being expressed by parents than did men; while men recollected more positive teachers' attitudes than did women. The Eccles and Jacobs (1986) explanation that parents' and teachers' attitudes may influence children's math attitudes, impacting on math anxiety and ultimately on math performance, seems a likely interpretation here as well. It should be noted that the path from math

socialization to general ability approached significance, indicating that in this sample of college students positive math socialization may be indirectly linked to math performance through the mediation of general ability. The use of a larger, more homogeneous sample in future structural models may clarify this issue as well as some of the other disparities between this study's findings and the previous research noted here.

An inverse relationship between math anxiety and math performance was clearly identified by Adams and Holcomb (1986) in a canonical analysis. The present findings revealed that participants who reported less math anxiety scored higher on the general ability factor, emphasizing this factor's mediating role in the relationship between math anxiety and math performance. Betz (1978) uncovered a negative relationship between math anxiety and years of high school math in a large sample of college students. A similar finding was revealed in Model 1; participants with more high school math experience reported significantly less math anxiety and scored significantly higher on the general ability factor than those with less math experience. This finding again calls attention to the significant mediational path between general ability and math performance.

The positive path from the math efficacy and attitude factor to general ability was quite high (approaching significance) and was also significantly related to both math socialization and math anxiety. The college students in this sample whose parents and teachers had expressed positive attitudes toward their math abilities scored higher on the math efficacy/attitude factor and also reported less math anxiety. This finding supports the results of previous research that showed math self-efficacy to be positively related to math achievement (Rounds & Hendel, 1980a) and negatively associated with math anxiety (Hackett, 1985). As Siegel et al. (1985) concluded, math self-efficacy may explain a

significant portion of the variance in math performance. In the Full Model, it may be the near significant path between the math efficacy/attitude factor and math performance that is contributing to the additional 15% explained variance in math performance that this model provided over and above that found in the Mediation Model which did not allow for this direct path. The fact that the path from the math efficacy/attitude factor to math performance did not reach significance may have been due to the need to treat math efficacy and math attitude as a single combined factor in order to fit this study's structural equation models. Future research should strive to measure these two variables in ways that allow them to maintain their distinct identities. By doing so, math self-efficacy may emerge more clearly as an explanation for a significant portion of the variance in math performance.

Math self efficacy and teacher expectations may also be related to classroom assertiveness. If math teachers do have higher expectations for boys, they may acknowledge them more readily, as the interview participants indicated. Consequently, boys may develop strong math self efficacy along with the assertiveness to take an active part in classroom exercises, volunteering answers and asking questions more often than girls. The concept of classroom assertiveness as it relates to math self efficacy, teachers' expectations, and ultimately performance, clearly warrants further investigation.

Overall, the results of the present study clarify conflicting findings concerning the predictors of mathematics performance. Much of the previous research has debated the role of sex in predicting math ability, some of it claiming that merely being male was an adequate predictor of enhanced math ability. The present study found no support for a direct link between sex and math performance, but does point to the relationship between

gender schema and the attitudes toward mathematics expressed by significant others, and the concurrent links between this socialization factor and math anxiety, math attitude, and math self-efficacy. Although causation can not be inferred by a correlational study of this nature, these results suggest that teachers' and parents' positive attitudes about children's math abilities may contribute to the development of strong math self-efficacy and a lessening of math anxiety. Future research might undertake the examination of multiple samples, investigating separate models for men and women in an attempt to further explain the roles of sex and gender in mathematics performance.

The views expressed by the interview participants concerning teachers' higher math expectations for boys than for girls, must be taken even more seriously in light of the quantitative data presented here. Particular attention should be focused on the respondents' experiences with this inequality as early as the formative grade school years and their assertions that these expectations continued to be manifested throughout junior high and high school. Undergraduate and graduate level teacher training programs should emphasize the magnitude of the impact that teachers' expectations can have on students' attitudes and feelings of efficacy in the realm of mathematics. By doing so, all children may be able to develop strong math self efficacy and positive math attitudes without acquiring the math anxiety that is often so debilitating. Future research should be undertaken to replicate and extend the current findings in girls and boys of elementary, middle school, and high school age to verify and further the understanding of the personality and socialization factors that may predict math performance. Particularly, research efforts should concentrate on the roles of parents and teachers in an attempt to dispel the myth that math is a male domain.

Appendix A

Demographic Data

1. Social Security Number: _____ - _____ - _____
2. Date of Birth: _____ - _____ - _____
month date year
3. Sex: (check one) _____ Female
 _____ Male
4. Status: (check one) _____ Freshman
 _____ Sophomore
 _____ Junior
 _____ Senior
5. Major: (check one) _____ Psychology
 _____ Sociology
 _____ Political Science
 _____ Computer Science
 _____ Business
 _____ Engineering
 _____ Mathematics
 _____ Other -- Specify _____
6. Is English your primary language?
 _____ Yes _____ No
7. Have you ever received, or are you now receiving, any Special Education services for a learning disability?
 _____ Yes _____ No
8. Would you be willing to return for a one hour interview?
 _____ Yes _____ Maybe _____ No

Appendix B

Bem Sex Role Inventory

Indicate how well each of the following items describes you by entering the appropriate number for the following scale. Answer as quickly and as honestly as possible.

1. Never or almost never true
2. Usually no true
3. Sometimes but infrequently true
4. Occasionally true
5. Often true
6. Usually true
7. Always true or almost always true

- | | |
|--|---|
| _____ 1. Self reliant | _____ 31. Makes decisions easily |
| _____ 2. Yielding | _____ 32. Compassionate |
| _____ 3. Helpful | _____ 33. Sincere |
| _____ 4. Defends own beliefs | _____ 34. Self sufficient |
| _____ 5. Cheerful | _____ 35. Eager to soothe hurt feelings |
| _____ 6. Moody | _____ 36. Conceited |
| _____ 7. Independent | _____ 37. Dominant |
| _____ 8. Shy | _____ 38. Soft spoken |
| _____ 9. Conscientious | _____ 39. Likable |
| _____ 10. Athletic | _____ 40. Masculine |
| _____ 11. Affectionate | _____ 41. Warm |
| _____ 12. Theatrical | _____ 42. Solemn |
| _____ 13. Assertive | _____ 43. Willing to take a stand |
| _____ 14. Flatterable | _____ 44. Tender |
| _____ 14. Happy | _____ 45. Friendly |
| _____ 16. Strong personality | _____ 46. Aggressive |
| _____ 17. Loyal | _____ 47. Gullible |
| _____ 18. Unpredictable | _____ 48. Inefficient |
| _____ 19. Forceful | _____ 49. Acts like a leader |
| _____ 20. Feminine | _____ 50. Childlike |
| _____ 21. Reliable | _____ 51. Adaptive |
| _____ 22. Analytical | _____ 52. Individualistic |
| _____ 23. Sympathetic | _____ 53. Does not use harsh language |
| _____ 24. Jealous | _____ 54. Unsympathetic |
| _____ 25. Has leadership abilities | _____ 55. Competitive |
| _____ 26. Sensitive to needs of others | _____ 56. Loves children |
| _____ 27. Truthful | _____ 57. Tactful |
| _____ 28. Willing to take risks | _____ 58. Ambitious |
| _____ 29. Understanding | _____ 59. Gentle |
| _____ 30. Secretive | _____ 60. Conventional |

Masculinity Score = sum of items 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31, 34, 37, 40, 43, 46, 49, 52, 55, 58.

Femininity Score = sum of items 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32, 35, 38, 41, 44, 47, 50, 53, 56, 59.

Appendix C

Math As A Male Domain Scale

Using the scale below fill in the number that indicates your amount of agreement or disagreement with the statements that follow.

1. Strongly disagree
2. Disagree
3. Undecided
4. Agree
5. Strongly agree

- | | |
|-------|---|
| _____ | 1. Females are as good as males in geometry. |
| _____ | 2. Studying mathematics is just as appropriate for women as for men. |
| _____ | 3. I would trust a woman just as much as I would trust a man to figure out important calculations.. |
| _____ | 4. Girls can do just as well as boys in mathematics. |
| _____ | 5. Males are not naturally better than females in mathematics. |
| _____ | 6. Women certainly are logical enough to do well in mathematics. |
| _____ | 7. It's hard to believe a female could be a genius in mathematics. * |
| _____ | 8. When a woman has to solve a math problem, it is feminine to ask a man for help. * |
| _____ | 9. I would have more faith in the answer for a math problem solved by a man than a woman. * |
| _____ | 10. Girls who enjoy math a are bit peculiar. * |
| _____ | 11. Mathematics is for men; arithmetic is for women. * |
| _____ | 12. I would expect a woman mathematician to be a masculine type of person. * |

Final score = sum of items 1 through 12 after reverse scoring of asterisked items.

Appendix E

Betz' Revised Fennema-Sherman Math Anxiety Scale

Using the scale below, fill in the number that indicates your amount of agreement or disagreement with the statements that follow.

1. Strongly disagree
2. Disagree
3. Undecided
4. Agree
5. Strongly agree

- | | |
|-------|--|
| _____ | 1. It wouldn't bother me at all to take more math courses. |
| _____ | 2. I have usually been at ease during math tests. |
| _____ | 3. I have usually been at ease in math courses. |
| _____ | 4. I usually don't worry about my ability to solve math problems. |
| _____ | 5. I almost never get uptight while taking math tests. |
| _____ | 6. I get really uptight during math tests. * |
| _____ | 7. I get a sinking feeling when I think of trying hard math problems. * |
| _____ | 8. My mind goes blank and I am unable to think clearly when working mathematics. * |
| _____ | 9. Mathematics makes me feel uncomfortable and nervous. * |
| _____ | 10. Mathematics makes me feel uneasy and confused. * |

Final score = sum of items 1 through 10 after reverse scoring of asterisked (*) items.

Appendix F

Benson's Math Self-Concept Scale

For the following items, use the scale given below to indicate your amount of agreement or disagreement.

1. Strongly disagree
2. Disagree
3. Undecided
4. Agree
5. Strongly agree

- | | |
|--|---|
| | 1. Working with math problems intrigues me. |
| | 2. I do not do well with courses that require computations. * |
| | 3. I enjoy math courses because they are exact. |
| | 4. I feel I am naturally good at math. |
| | 5. I feel I do not have the aptitude for math courses. * |
| | 6. I feel insecure in a math class. * |
| | 7. I find it hard to think in terms of symbols. * |

Final score = sum of items 1 through 10 after reverse scoring of asterisked (*) items.

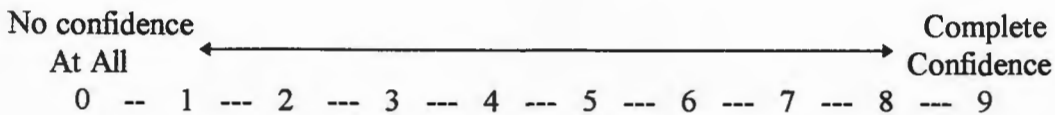
Appendix G

Mathematics Self-Efficacy: Math Tasks

For the following items, indicate your confidence in your ability to successfully perform each task. Use a scale from 0 to 9 where

0 = No confidence at all

9 = Complete confidence



- ___ 1. Work with a slide rule
- ___ 2. Determine how much interest you will end up paying on a \$675 loan over 2 years at 14.75% interest.
- ___ 3. Figure out how much lumber you need to buy in order to build a set of bookshelves.
- ___ 4. Compute your income taxes for the year.
- ___ 5. Figure out how much material to buy in order to make curtains.
- ___ 6. Understand a graph accompanying an article on business profits.
- ___ 7. Understand how much interest you will earn on your savings account in 6 months, and how that interest is compounded.
- ___ 8. Add two large numbers (e.g., $5739 + 62543$) in your head.
- ___ 9. Estimate your grocery bill in your head as you pick items.
- ___ 10. Determine the amount of sales tax on a clothing purchase.
- ___ 11. Figure out the tip on your part of a dinner bill split 8 ways.
- ___ 12. Figure out how long it will take to travel for City A to City B driving at 55 mph.
- ___ 13. Compute your car's gas mileage.
- ___ 14. Set up a monthly budget for yourself.
- ___ 15. Balance your checkbook without a mistake.
- ___ 16. Figure out which of two summer jobs is the better offer: one with a higher salary but no benefits, the other with a lower salary plus room, board, and travel expenses.
- ___ 17. Figure out how much you would save if there is a 15% markdown on an item you wish to buy.
- ___ 18. Calculate recipe quantities for a dinner for 41 when the original recipe is for 12 people.

Final Score = sum of items 1 through 18.

Appendix H

Aiken's Attitude Toward Mathematics Scale

For the following items, use the scale given below to indicate your amount of agreement or disagreement.

1. Strongly disagree
2. Disagree
3. Undecided
4. Agree
5. Strongly agree

- | | |
|-------|--|
| _____ | 1. Mathematics is not a very interesting subject. * |
| _____ | 2. I want to develop my mathematical skills and study this subject more. |
| _____ | 3. Mathematics is a very worthwhile and necessary subject. |
| _____ | 4. Mathematics makes me feel nervous and uncomfortable. * |
| _____ | 5. I have usually enjoyed studying mathematics in school. |
| _____ | 6. I don't want to take any more mathematics than I have to. * |
| _____ | 7. Other subjects are more important to people than mathematics. * |
| _____ | 8. I am very calm when studying mathematics. |
| _____ | 9. I have seldom liked studying mathematics. * |
| _____ | 10. I am interested in acquiring further knowledge of mathematics. |
| _____ | 11. Mathematics helps to develop the mind and teaches a person to think. |
| _____ | 12. Mathematics makes me feel uneasy and confused. * |
| _____ | 13. Mathematics is enjoyable and stimulating to me. |
| _____ | 14. I am not willing to take more than the required amount of mathematics. * |
| _____ | 15. Mathematics is not especially important to everyday life. * |
| _____ | 16. Trying to understand mathematics doesn't make my anxious. |
| _____ | 17. Mathematics is dull and boring. * |
| _____ | 18. I plan to take as much mathematics as I can during my education. |
| _____ | 19. Mathematics has contributed greatly to the advancement of civilization. |
| _____ | 20. Mathematics is one of my most dreaded subjects. * |
| _____ | 21. I like trying to solve new problems in mathematics. |
| _____ | 22. I am not motivated to work very hard on mathematics lessons. * |
| _____ | 23. Mathematics is not one of the most important subjects for people to study. * |
| _____ | 24. I don't get upset when trying to do mathematics lessons. |

Final score = sum of items 1 through 20 after reverse scoring of asterisked (*) items.

Appendix I

Fennema-Sherman Usefulness of Math Subscale

Using the scale below, fill in the number that indicates your amount of agreement or disagreement with the statements that follow.

1. Strongly disagree
2. Disagree
3. Undecided
4. Agree
5. Strongly agree

- | | |
|-------|--|
| _____ | 1. I'll need mathematics for my future. |
| _____ | 2. I study mathematics because I know how useful it is. |
| _____ | 3. Knowing mathematics will help me earn a living. |
| _____ | 4. Mathematics is a worthwhile and necessary subject. |
| _____ | 5. I'll need a firm mastery of mathematics for my future. |
| _____ | 6. I will use mathematics in many ways as an adult. |
| _____ | 7. Mathematics is of no relevance to my life. * |
| _____ | 8. Mathematics will not be important to me in my life's work. * |
| _____ | 9. I see mathematics as a subject I will rarely use in my daily life as an adult. * |
| _____ | 10. Taking mathematics is a waste of time. * |
| _____ | 11. In terms of my adult life, it is not important for me to do well in mathematics. * |
| _____ | 12. I expect to have little use for mathematics when I get out of school. * |

Final score = sum of items 1 through 12 after reverse scoring of asterisked (*) items.

Appendix J

Math Experience

Part I: High School

Please check below the math courses you successfully completed in high school.

- _____ Basic Math
- _____ Algebra I
- _____ Algebra II
- _____ Geometry
- _____ Pre-Calculus
- _____ Calculus
- _____ Trigonometry
- _____ Other -- Specify _____
- _____ Other -- Specify _____
- _____ Other -- Specify _____
- _____ Other -- Specify _____

Part II: college

For each of the subject areas listed below, please indicate the number of semesters you have successfully completed in college.

- _____ Basic Math
- _____ Basic Algebra and/or Trigonometry
- _____ Finite Mathematics
- _____ Pre-Calculus
- _____ Applied Calculus
- _____ Calculus with Analytic Geometry
- _____ Linear algebra
- _____ Other -- Specify _____
- _____ Other -- Specify _____
- _____ Other -- Specify _____
- _____ Other -- Specify _____

Appendix K

Fennema-Sherman Teacher's Attitude Toward Math Subscale

Using the scale below, fill in the number that indicates your amount of agreement or disagreement with the statements that follow.

1. Strongly disagree
2. Disagree
3. Undecided
4. Agree
5. Strongly agree

- _____ 1. My teachers have encouraged me to study more mathematics.
- _____ 2. My teachers think I'm the kind of person who could do well in mathematics.
- _____ 3. Math teachers have made me feel I have the ability to go on in mathematics.
- _____ 4. My math teachers would encourage me to take all the math I can.
- _____ 5. My math teachers have been interested in my progress in mathematics.
- _____ 6. I would talk to my teachers about a career which uses mathematics.
- _____ 7. When it comes to anything serious I have felt ignored when talking to math teachers. *
- _____ 8. I have found it hard to win the respect of math teachers. *
- _____ 9. My teachers think advanced math is a waste of time for me. *
- _____ 10. Getting a mathematics teacher to take me seriously has usually been a problem. *
- _____ 11. My teachers would think I wasn't serious if I told them I was interested in a career in science and mathematics. *
- _____ 12. I have had a hard time getting teachers to talk seriously with me about mathematics. *

Final score = sum of items 1 through 12 after reverse scoring o asterisked (*) items.

Appendix L

Fennema-Sherman Mother's Attitude Toward Math Subscale

Using the scale below, fill in the number that indicates your amount of agreement or disagreement with the statements that follow.

1. Strongly disagree
2. Disagree
3. Undecided
4. Agree
5. Strongly agree

- | | |
|-------|--|
| _____ | 1. My mother thinks I'm the kind of person who could do well in mathematics. |
| _____ | 2. My mother thinks I could be good in math. |
| _____ | 3. My mother has always been interested in my progress in mathematics. |
| _____ | 4. My mother has strongly encouraged me to do well in mathematics. |
| _____ | 5. My mother thinks that mathematics is one of the more important subjects I have studied. |
| _____ | 6. My mother thinks I'll need mathematics for what I want to do after I graduate. |
| _____ | 7. My mother thinks advanced math is a waste of time for me. * |
| _____ | 8. As long as I have passed, my mother hasn't cared how I have done in math. * |
| _____ | 9. My mother wouldn't encourage me to plan a career which involves math. * |
| _____ | 10. My mother has shown no interest in whether or not I take more math courses. * |
| _____ | 11. My mother thinks I need to know just a minimum amount of math. * |
| _____ | 12. My mother hates to do math. * |

Final score = sum of items 1 through 12 after reverse scoring o asterisked (*) items.

Appendix M

Fennema-Sherman Father's Attitude Toward Math Subscale

Using the scale below, fill in the number that indicates your amount of agreement or disagreement with the statements that follow.

1. Strongly disagree
2. Disagree
3. Undecided
4. Agree
5. Strongly agree

- | | |
|-------|--|
| _____ | 1. My father thinks that mathematics is one of the most important subjects I have studied. |
| _____ | 2. My father has strongly encouraged me to do well in mathematics. |
| _____ | 3. My father has always been interested in my progress in mathematics. |
| _____ | 4. My father thinks I'll need mathematics for what I want to do after I graduate.. |
| _____ | 5. My father thinks I'm the kind of person who could do well in mathematics. |
| _____ | 6. My father thinks I could be good in math. |
| _____ | 7. My father wouldn't encourage me to plan a career which involves math. * |
| _____ | 8. My father hates to do math. * |
| _____ | 9. As long as I have passed, my father hasn't cared how I have done in math. * |
| _____ | 10. My father thinks advanced math is a waste of time for me. *
math courses. * |
| _____ | 11. My father thinks I need to know just a minimum amount of math. * |
| _____ | 12. My father has shown no interest in whether or not I take more |

Final score = sum of items 1 through 12 after reverse scoring o asterisked (*) items.

Appendix N

Follow-Up Interview Schedule

1. In general, how do you feel about math?
2. What factors contribute to your feelings?
3. How did you do in math in grade school?
4. How did your parents respond to you grade school math performance?
5. Did your mother and father have different attitudes about your math performance?
6. In grade school, did you think boys and girls had equal math abilities?
7. Were girls and boys treated equally in grade school math classes?
8. Were the expectations of grade school math teachers the same for boys and girls?
9. What about junior high? Were girls and boys treated equally in math classes?
10. Did you think boys and girls had equal math abilities at this level?
11. How did your parents respond to your performance in junior high math classes?
12. Were the expectations of junior high math teachers the same for boys and girls?
13. What about high school? Were girls and boys treated equally in math classes?
14. Did you think boys and girls had equal math abilities at this level?
15. Were the expectations of high school math teachers the same for boys and girls?
16. Did your parents have different attitudes about your high school math performance?
17. How about now? Do you think that men and women have equal math abilities?
18. Do you think that women who excel in math are, in any way, less feminine?
19. Do you think that men who do not do well in math are somehow less masculine?

Simple “yes” and “no” responses were probed for more detailed information.

Table 1

Pearson's Correlations Among Dependent Measures

	Wonderlic	SAT-V	SAT-M
Wonderlic	1.00		
SAT-V	.62*	1.00	
SAT-M	.44*	.51*	1.00

* $p < .05$

Table 2

Factor Loadings for Six-Component PCA Solution

Measured Variables	Factors					
	1	2	3	4	5	6
X1 Sex	-.05	.15	.84*	.01	-.25	-.01
X2 BSRI-Masculine	.15	.03	-.46*	-.57*	.45	-.17
X3 BSRI-Feminine	.05	-.09	.72*	-.14	.15	-.23
X4 Math as Male Domain	.17	.55*	.48*	-.27	-.07	-.27
X5 Math Anxiety Rating Scale	.04	.02	.06	.01	-.81*	-.08
X6 Math Anxiety Scale	.71*	.23	-.17	.27	.32	.45
X7 Math Self-Concept	.82*	.20	-.26	.27	.17	.40
X8 Math Self-Efficacy - Tasks	.55*	.44	-.30	-.08	.45	.00
X9 Attitudes Toward Math	.86*	.14	-.15	.24	.16	.39
X10 Usefulness of Math	.75*	.16	-.01	.08	-.02	.17
X11 High School Math	.26	.30	-.01	.11	.13	.70*
X12 College Math	.31	-.01	-.20	.15	.06	.620*
X13 Teacher's Attitude	.73*	.23	-.12	.21	.16	.20
X14 Mother's Attitude	.74*	.23	.13	.06	-.09	-.10
X15 Father's Attitude	.73*	.34	.10	.07	.04	.05
Y1 SAT-V	.34	.63*	-.13	.40	.04	.33
Y2 SAT-M	.12	.79*	.01	.29	-.14	.18
Y3 Wonderlic	.20	.83*	.02	.22	.17	.06
Y4 GRE-Q -- Odd	.31	.41	-.05	.68*	.10	.07
Y5 GRE-Q -- Even	.33	.30	-.22	.72*	.10	.19

Note. Factor 1 = Personality/Socialization; Factor 2 = Cognitive Ability; Factor 3 = Gender-Schema; Factor 4 = Math Performance; Factor 5 = Lack of Math Anxiety; Factor 6 = Math Experience.

* $p < .05$.

Table 3

Descriptive Statistics for the Final Set of Measured Variables (N = 214)

Measured Variables	Descriptive Statistics		
	<u>Range</u>	<u>M</u>	<u>SD</u>
X1 Sex	.00 - 1.00	.66	.47
X2 BSRI-Masculine	48.00 - 131.00	98.17	16.20
X3 BSRI-Feminine	65.00 - 126.00	99.66	12.86
X4 Math as Male Domain	30.00 - 60.00	52.82	7.38
X5 Math Anxiety Rating Scale	24.00 - 120.00	50.72	21.26
X6 Math Anxiety Scale	10.00 - 50.00	23.04	9.99
X7 Math Self-Concept	2.00 - 34.00	20.00	6.75
X8 Math Self-Efficacy - Tasks	20.00 - 162.00	110.61	27.82
X9 Attitudes Toward Math	27.00 - 115.00	67.81	17.13
X10 Usefulness of Math	12.00 - 60.00	41.79	9.81
X11 High School Math	1.00 - 8.00	4.72	1.18
X12 College Math	.00 - 6.00	1.03	1.05
X13 Teacher's Attitude	12.00 - 60.00	40.74	8.73
X14 Mother's Attitude	13.00 - 60.00	41.49	9.06
X15 Father's Attitude	12.00 - 62.00	42.31	8.97
Y1 SAT-V	290.00 - 690.00	443.70	64.48
Y2 SAT-M	220.00 - 720.00	491.82	73.20
Y3 Wonderlic	10.00 - 34.00	22.26	4.39
Y4 GRE-Q -- Odd	0.00 - 9.00	4.11	1.73
Y5 GRE-Q -- Even	0.00 - 12.00	4.61	2.02

Note. M = Mean; SD = Standard Deviation

Table 4

Pattern of Means by Sex

Variable	Men	Women
Math Anxiety	23.21	22.96
Math Self-Efficacy	118.24**	106.74
Math Attitude	68.92	67.25
High School Experience	4.61	4.78
College Experience	1.26*	.91
Teachers' Attitudes	41.14	40.53
Mother's Attitude	40.58	41.94
Father's Attitude	41.85	42.55
SAT-Verbal	432.60	449.33
SAT-Math	487.80	493.86
Wonderlic	21.44	22.68
Math Performance	4.47	4.303

*p = .019, **p = .004

Table 5

Pattern of Means by Gender Schema

Variable	Andro.	Masc.	Fem.	Und.
Math Anxiety	22.50	22.95	24.02	22.73
Math Self-Efficacy	115.79	112.273	106.28	107.22
Math Attitude	69.84	67.47	65.94	67.81
High School Experience	4.58	4.91	1.18	1.18
College Experience	1.00	1.14	.96	1.03
Teachers' Attitudes	40.27	41.49	40.70	40.74
Mother's Attitude	40.62	41.02	42.45	41.49
Father's Attitude	42.22	42.74	42.94	42.31
SAT-Verbal	425.61	443.55	444.73	464.59
SAT-Math	470.78	489.62	488.17	523.81
Wonderlic	22.21	22.04	22.70	22.10
Math Performance	3.94	4.26	4.62	4.69

Note. Andro. = Androgynous; Masc. = Masculine; Fem. = Feminine; Und. = Undifferentiated

Table 6

Correlations Among Exogenous Measured and Latent Variables in Models 1,2, and 3

Variables	Sex	GS	MA	E/A	HS
GS	.36***				
	.36***				
	.36***				
MA	-.01	.01			
	-.01	.01			
	-.01	.01			
E/A	-.08	.01	-.83***		
	-.08	.01	-.83***		
	-.08	.01	-.83***		
HS	.07	.05	-.32***	.34***	
	.07	.05	-.32***	.34***	
	.07	.05	-.32***	.34***	
MS	.04	.22**	-.59***	.86***	.27**
	.04	.22**	-.59***	.86***	.27**
	.04	.22**	-.59***	.86***	.27**

Note. Correlations for Model 1 appear in the first row, Model 2 in the second row, Model 3 in the third row. GS = Gender Schema; MA = Math Anxiety; E/A = Math Efficacy and Attitude; HS = High School Math Experience; MS = Math Socialization.

** $p < .01$, *** $p < .001$

FIGURE CAPTIONS

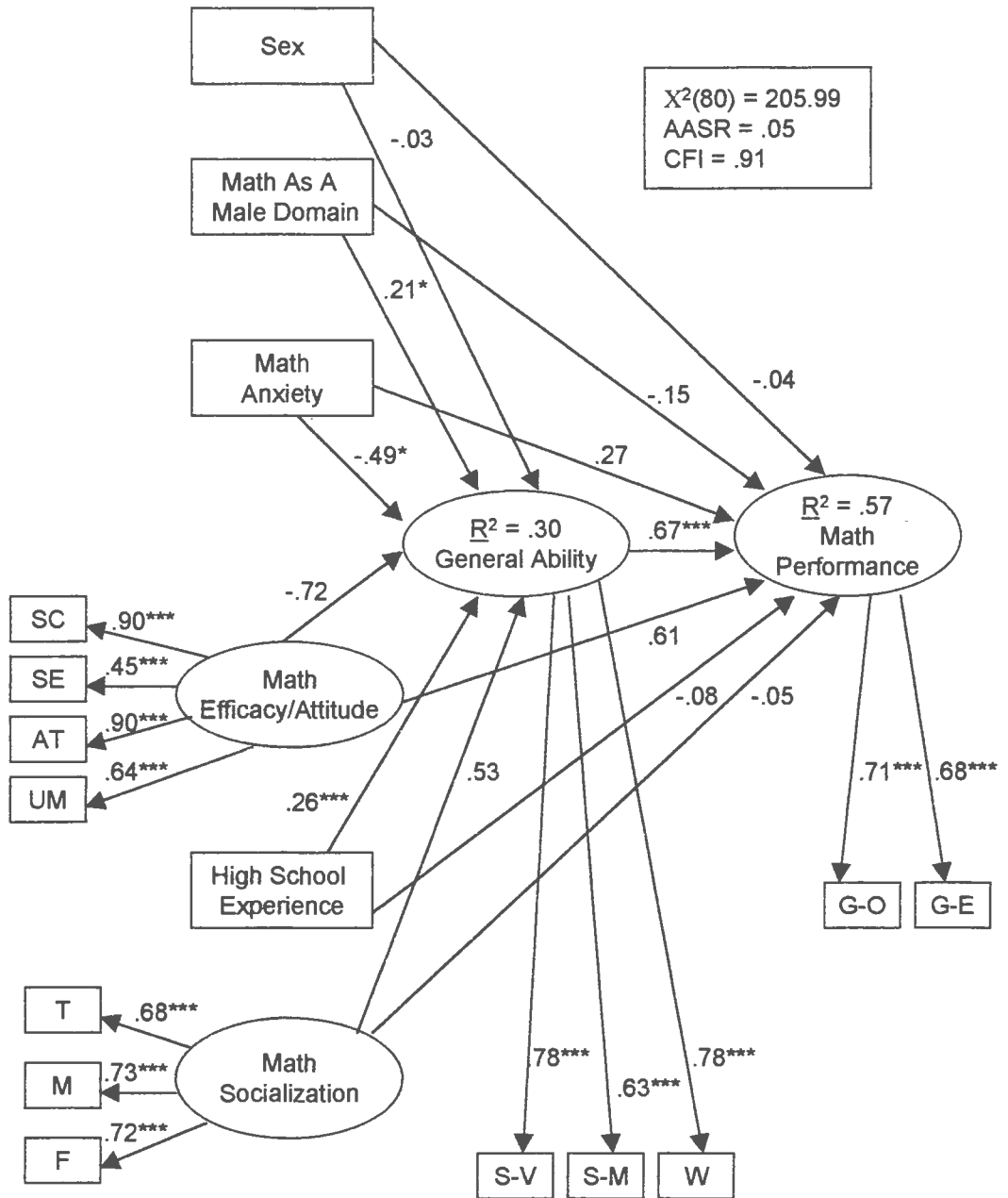
Figure 1. Model 1: Structural equation model of the relationships among background and personality measures and constructs, general ability, and mathematics performance (excluding paths among exogenous measured and latent variables).

Figure 2. Model 2: Structural equation model of the relationships among background and personality measures and constructs and mathematics performance with all paths to and from the mediating variable (general ability) removed; paths among exogenous measured and latent variables have been excluded.

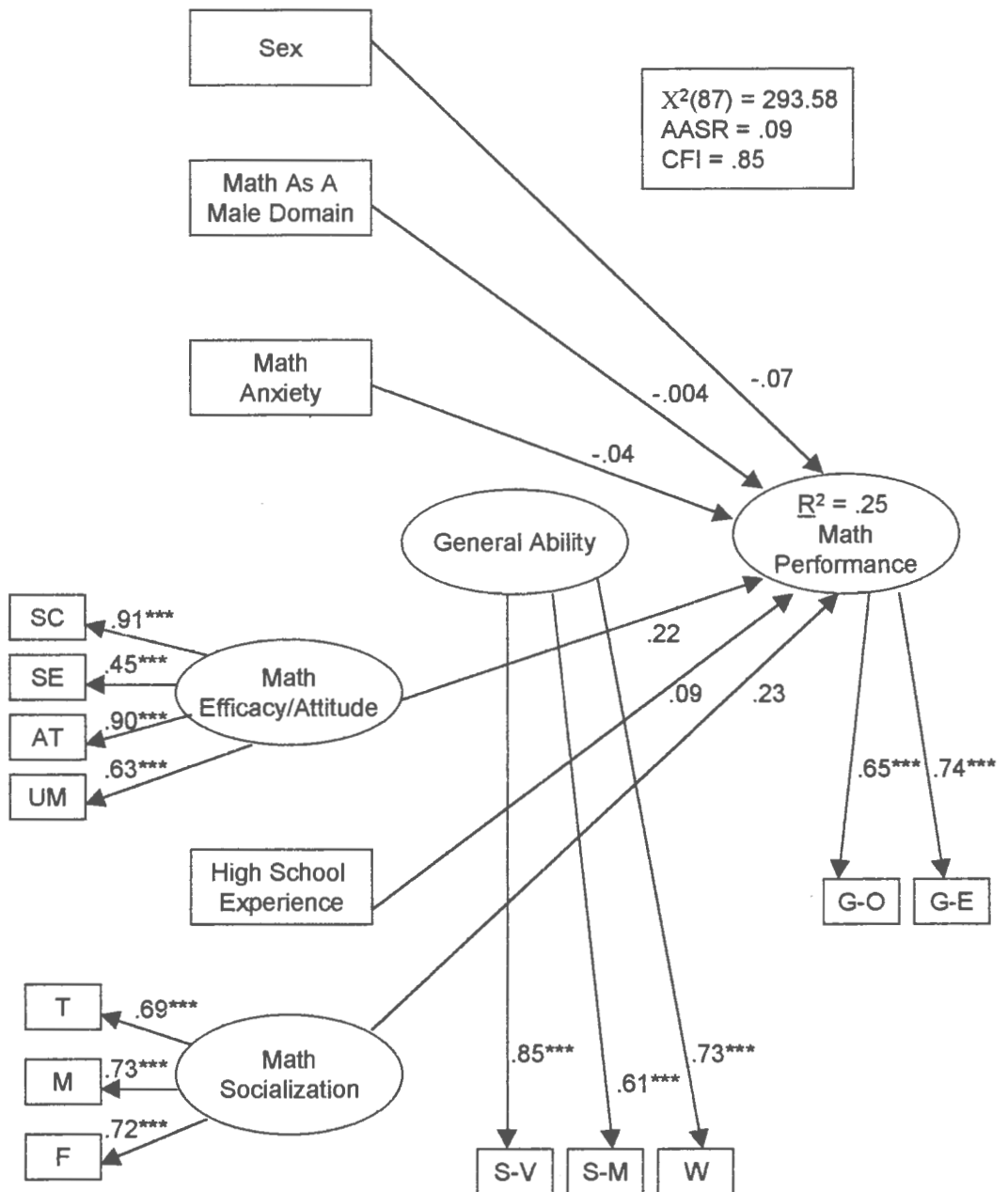
Figure 3. Model 3: Structural equation model for mathematics performance with direct paths from background and personality measures and constructs to math performance removed; paths among exogenous measured and latent variables have been excluded.

Figure 4. Model 4: Structural equation model for mathematics performance with the paths from background and personality measures and constructs to general ability removed (displaying significant paths only).

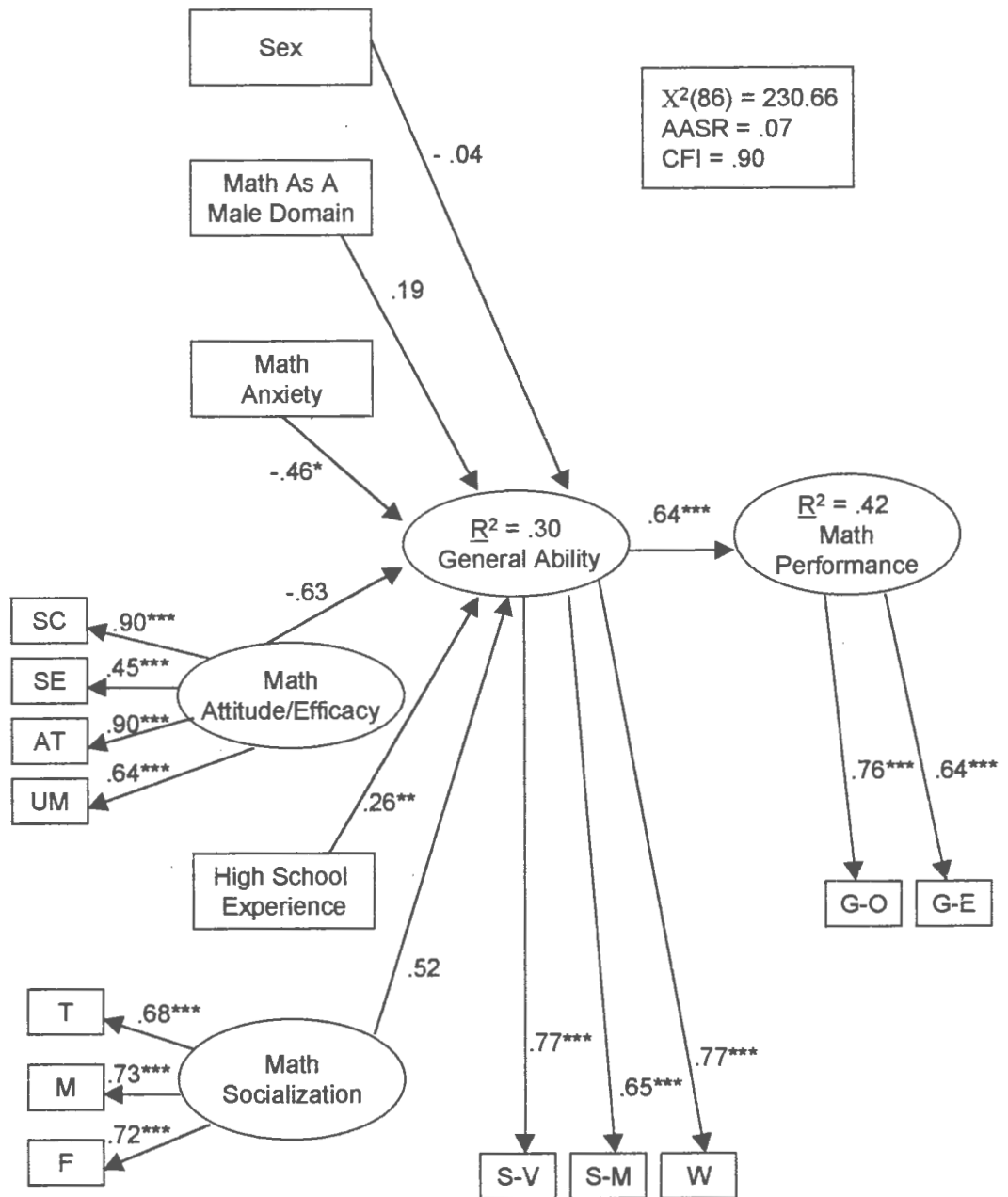
Figure 5. Model 5: Structural equation model for mathematics performance combining significant paths from the previous models (displaying significant paths only).



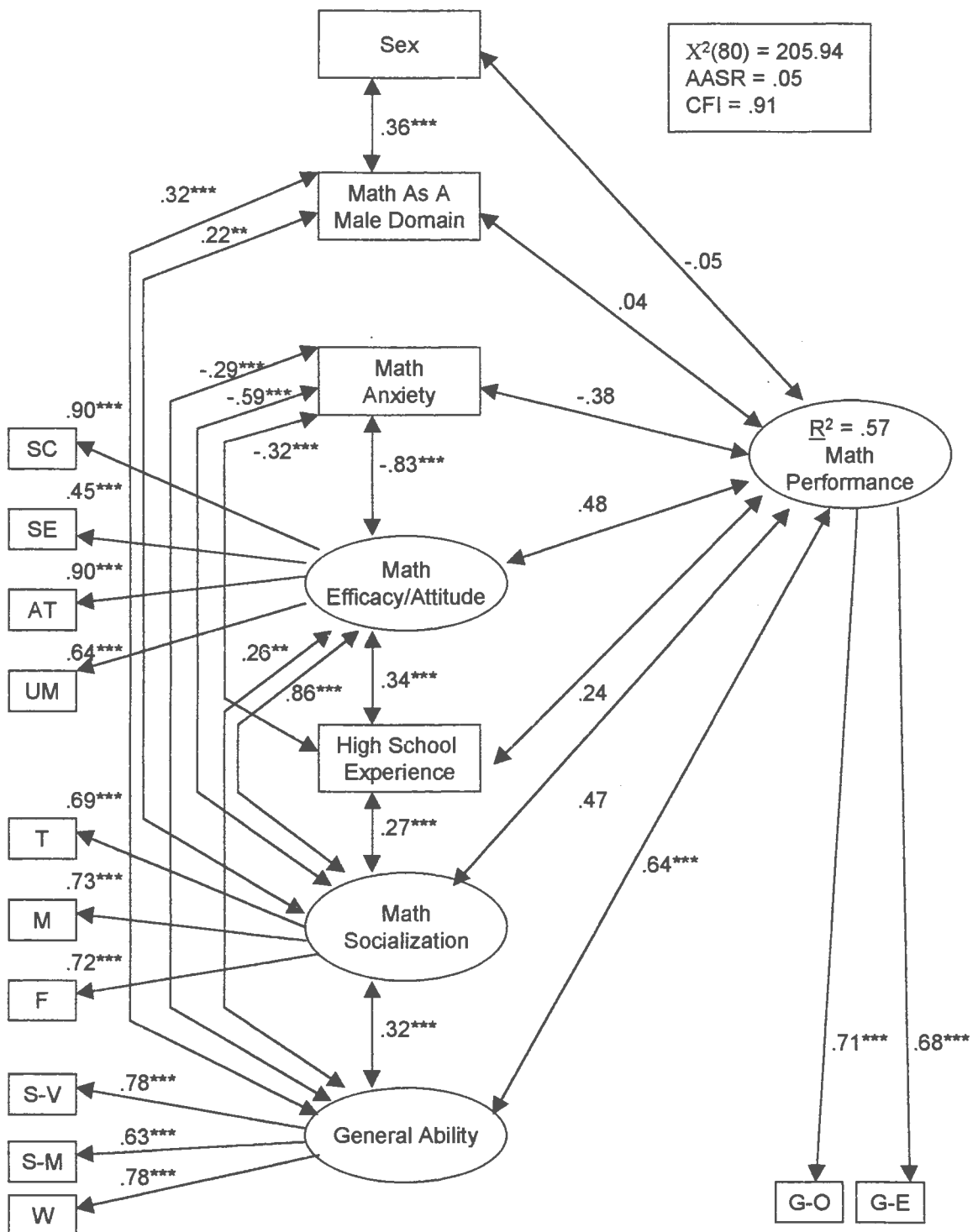
Note. $^*p < .05$, $^{***}p < .001$; SC = Math Self-Concept, SE = Math Self-Efficacy, AT = Math Attitude, UM = Usefulness of Math, T = Teachers' Attitude, M = Mother's Attitude, F = Father's Attitude, S-V = SAT-Verbal, S-M = SAT-Math, W = Wonderlic, G-O = GRE-Odd, G-E = GRE-Even. See Table 6 for correlations among exogenous measured and latent variables.



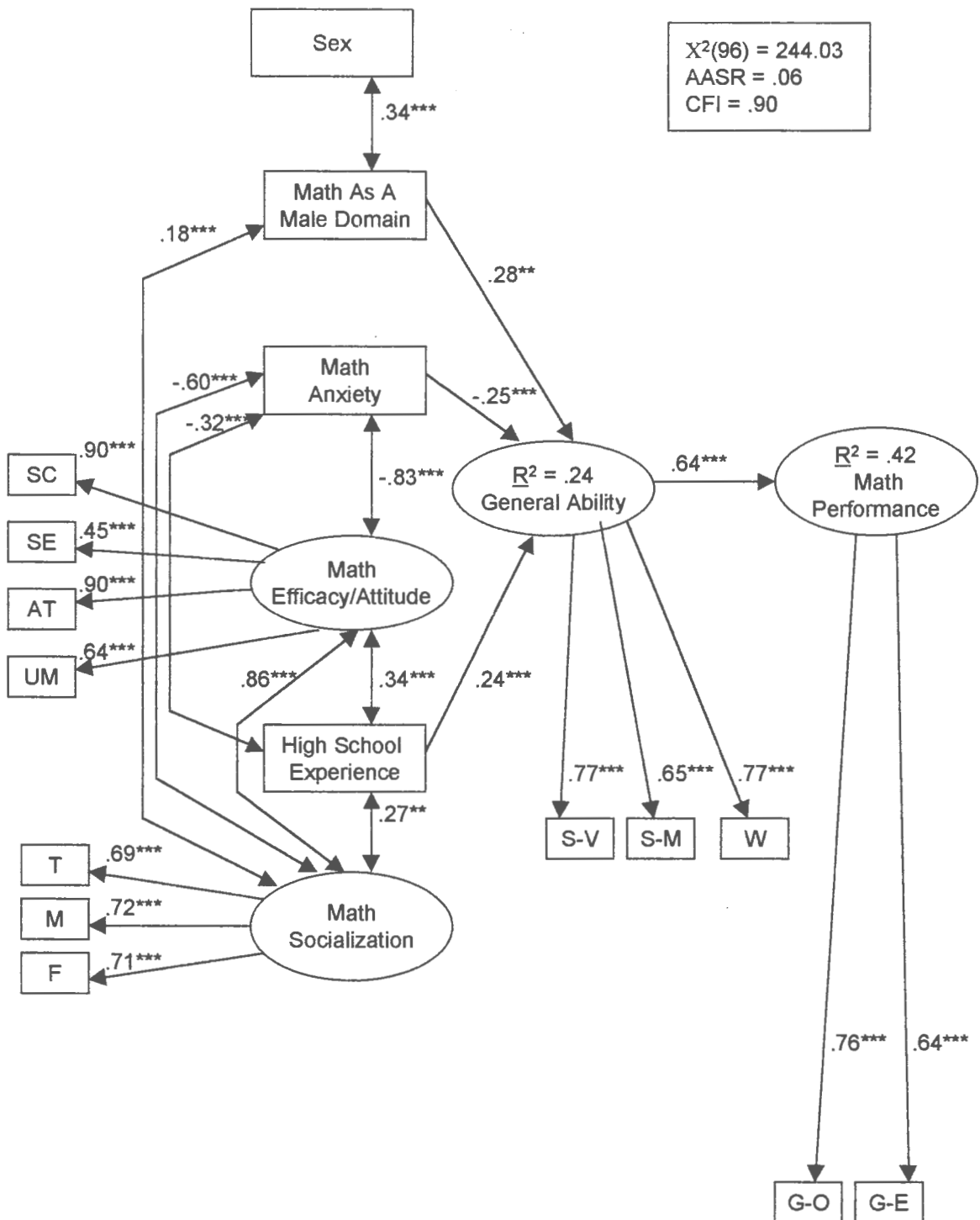
Note. *** $p < .001$; SC = Math Self-Concept, SE = Math Self-Efficacy, AT = Math Attitude, UM = Usefulness of Math, T = Teachers' Attitude, M = Mother's Attitude, F = Father's Attitude, S-V = SAT-Verbal, S-M = SAT-Math, W = Wonderlic, G-O = GRE-Odd, G-E = GRE-Even. See Table 6 for correlations among exogenous measured and latent variables.



Note. $^*p < .05$, $^{**}p < .01$, $^{***}p < .001$; SC = Math Self-Concept, SE = Math Self-Efficacy, AT = Math Attitude, UM = Usefulness of Math, T = Teachers' Attitude, M = Mother's Attitude, F = Father's Attitude, S-V = SAT-Verbal, S-M = SAT-Math, W = Wonderlic, G-O = GRE-Odd, G-E = GRE-Even. See Table 6 for correlations among exogenous measured and latent variables.



Note. ** $p < .01$, *** $p < .001$; SC = Math Self-Concept, SE = Math Self-Efficacy, AT = Math Attitude, UM = Usefulness of Math, T = Teachers' Attitude, M = Mother's Attitude, F = Father's Attitude, S-V = SAT-Verbal, S-M = SAT-Math, W = Wonderlic, G-O = GRE-Odd, G-E = GRE-Even.



Note. *** $p < .001$; SC = Math Self-Concept, SE = Math Self-Efficacy, AT = Math Attitude, UM = Usefulness of Math, T = Teachers' Attitude, M = Mother's Attitude, F = Father's Attitude, S-V = SAT-Verbal, S-M = SAT-Math, W = Wonderlic, G-O = GRE-Odd, G-E = GRE-Even

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